

Evidence for the Extinction of Mammoths by an Extraterrestrial Impact Event*

R.B. Firestone¹ and A. West²

¹ Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720

² Geosciences Consulting, Arizona 85259 U.S.A.

At Paleo-Indian kill sites throughout North America abundant fossil evidence exists for Mammoths, dated to $\approx 11,000$ rcy BP (13,000 cal yr BP), often fully articulated and partly butchered, whose remains could not have been exposed to the elements for more than a short time. They appear to be the victims of a sudden, catastrophic event. At several sites a black mat lies in direct contact with the bones. No evidence for Mammoths, or the Paleo-Indians who hunted them, is found in later sediments. We have investigated Paleo-Indian sites at Gainey, MI, Murray Springs, AZ, and Blackwater Draw, NM where we discovered a layer of abundant, rounded, ferromagnetic particles in direct contact with the Mammoth fossils (Figure 1). These particles can be readily extracted from the sediment with a strong permanent magnet. The magnetic particles at Murray Springs and Blackwater Draw appear more weathered than those at Gainey. Figure 2 shows the distribution of particles in the sediment at Murray Springs. Magnetic particles are not usually found in sediments, so the large abundance, $>0.1\%$ by weight, below the black mat is remarkable.

In addition to the impact evidence at Gainey, Murray Springs and Blackwater Draw, we have discovered a Mammoth tusk containing at least six micrometeorites embedded in the bark. The largest one, shown in Figure 3, is 4 mm in diameter surrounded by a carbonized ring. Each of the embedded micrometeorites strongly attracts a magnet indicating significant iron content. The condition of the tusk suggests that it dates to the late Pleistocene, and radiocarbon and palynological dating are planned. If our attribution of the tusk is correct, it provides prima facie evidence that Mammoths were directly impacted by high velocity micrometeorites and likely killed. Presumably this would have been a major, if not determining factor in the extinction of Mammoths and other megafauna.

* Paper presented at the 2nd International World of Elephants Congress, Hot Springs, South Dakota, September 22-25, 2005.



Figure 1. Magnetic particles from the Gainey MI site. Shown are a black, highly magnetic particle and a translucent perfectly spherical particle.

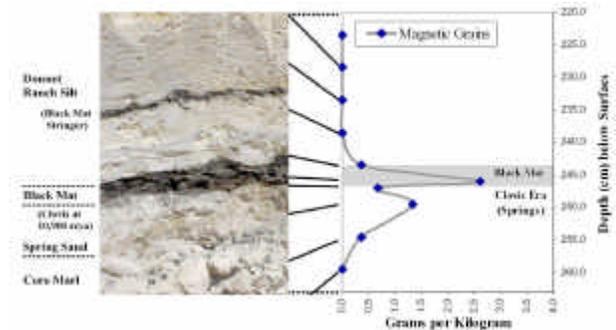


Figure 2. Distribution of magnetic particles in the sediment at Murray Springs. The particle density is strongly peaked near the bottom of the black mat, although some particles appear to have mixed into older sediments.

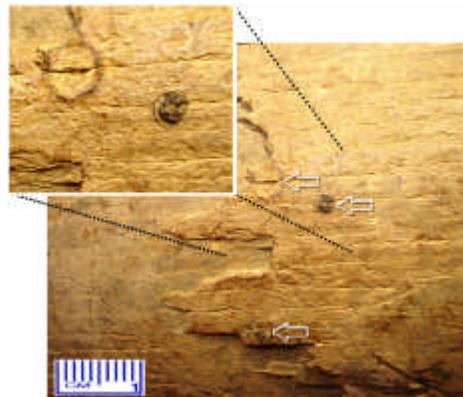


Figure 3. Embedded micrometeorites surrounded by carbonized rings in the bark of a Mammoth tusk. The inclusions all attract a magnet suspended nearby.